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955 L'ENFANT PLAZA NORTH, S.W. WASHINGTON, D. C. 20024

B70 01012

SUBJECT: Operational Constraints for J Mission Traverse Planning - Case 320

DATE: January 7, 1970

FROM: P. Benjamin

ABSTRACT

A framework for the construction of lunar surface traverses is created, consistent with the requirements and constraints of the J missions. The framework represents the results of Apollo 11 and Apollo 12 experience altered for J mission requirements and constraints with projections for increased technological capability and confidence. Nominal and real time alternate timelines for the 54 hour lunar surface stay are developed. Three 6 hour EVA's and two 7 hour rest periods are provided. A configuration with two 9 hour EVA's and three 6 hour rest periods is also evaluated.

Both the LRV and MALSEP are assumed to be carried. All non-traverse activities required for each EVA are identified and the time available for the traverse determined. On EVA 1 the traverse is 2 hours and 20 minutes long, 4 hours are available for the traverse in EVA 2, and the EVA 3 traverse has a length of 3 hours and 40 minutes. The currently agreed upon program assumptions for riding and science activity metabolic rates are used and nomographs for the calculation of traverse distance versus science time available are presented. It is assumed that the A7LB suit and -7 PLSS are used. It is noted that for the longer traverses the time and PLSS consumables limits are evenly matched and that consumables constrain the shorter traverse.

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MEMORANDUM FOR FILE

INTRODUCTION

In order to perform J mission traverse planning, it is necessary to determine the context and constraints which define the character of each EVA. Three specific items are considered here: the scheduling of the 3 EVA's within the 54 hour lunar surface timeline, the determination of the time available in each EVA for the geologic traverse, and the calculation of the resulting time and consumables constraints. Together these form the context within which traverses may be designed.

LUNAR SURFACE STAY TIMELINE

It is assumed that the maximum possible portion of the 54 hour lunar stay will be used for EVA. Consequently three 6 hour EVA's are planned here. This represents the maximum total EVA time available consistent with provisions for adequate rest and total stay time limitations, and would appear at this time to be within the capabilities of the A7LB suit and -7 PLSS proposed for these missions. Extension of EVA time beyond 6 hours would require a reduction in the number of EVA's, a decrease in rest time, modification of pre and post EVA procedures, or an increase in surface stay time.

The timelines proposed here represent the results of Apollo 11 and Apollo 12 experience projected into the extended surface stay. The timelines provide two 7 hour rest periods, 2 hours of post touchdown checkout, and 2 hours for liftoff preparation (and eating). Two hours are provided for EVA preparations prior to each EVA, and 2 hours for post EVA activity. Exceptions are the 2 1/2 hours provided before the first EVA and after the last EVA. Any changes in the pre and post EVA procedures which would significantly reduce the times involved could result in either longer rest periods or longer EVA times.

The author's preferred timeline, Plan A, is shown in Figure 1. The 3 EVA's are on 3 separate days, separated by the 2 sleep periods, providing an evenly balanced timeline. The sun angle is shown at the beginning of each EVA, assuming 7° sun angle at touchdown. The time since the last rest period is shown prior to each rest. This reveals the disadvantage of the balanced plan: TD and LO days are both very long, with a very short day between.

Because of the brevity of the second day it is quite possible that the crew would prefer to do a second EVA prior to resting, giving rise to the real time alternate shown in Figure 2. In this case the first two days are long and LO day is of normal length. The choice between Plan A and its real time alternate can be made at any time prior to the scheduled rest period at 33.5 hours, providing significant flexibility for the crew.

Should TD day be longer than anticipated for any reason, or should the crew be overly tired, Plan B shown in Figure 3 can be substituted. This provides a rest period immediately upon landing, followed by 2 EVA's on a long second day and the remaining EVA on LO day. These three timeline options are summarized in Figure 4.

Continued development may permit suit times and PLSS capacities sufficient for significantly longer EVA's. In this case the 18 hours available for EVA may be divided into two 9 hour EVA's as shown in Figure 5. Extended EVA's allow longer traverses at greater ranges from the LM, thereby increasing the significant scientific yield. Although the individual rest periods are 1 hour shorter, the total rest time on the surface is increased by 4 hours over the previous plans. In addition the three rest periods provided create an evenly balanced 4 day surface timeline with no long days. No EVA's are conducted on TD or LO days, and there are no back-to-back EVA's. These factors indicate the value of longer EVA's, if they are compatible with EMU capability. Extension of the lunar surface stay time by 24 hours would provide 1 additional 6 or 9 hour EVA and slightly longer rest periods.

EVA TIMELINES

The 3 EVA's as presented here are planned to consume the full 6 hours allotted. The times proposed for the activities shown represent the results of Apollo 11 and Apollo 12 experience modified by the requirements for J mission activities. All timelines are from depress to repress, and the time available for the traverse is that remaining after all other required activities have been provided for. As is shown below, this time is different for each EVA.

It is assumed that both an LRV and a MALSEP will be carried on these missions, and MALSEP deployment is scheduled for the first EVA, shown in Figure 6. The first hour of the EVA is used for the basic activities common to all missions with the exception that the LRV deployment mechanism is activated during CDR egress. The second hour is devoted to MALSEP deployment, assumed here to occur near enough to the LM to make walking to the site more attractive than loading MALSEP on the LRV. A large portion of the third hour is consumed in the completion of LRV deployment, offloading appropriate equipment from the LM and mounting it on the LRV, and a preliminary LRV checkout. The next 2 hours and 20 minutes are used for the first LRV traverse, and the final portion of the EVA involves offloading the LRV, packing and transferring samples into the LM, and ingress.

The second EVA, shown in Figure 7, provides the longest traverse time, 4 hours. Minimal activities precede LRV preparation, and the traverse begins at the beginning of the second hour. Less than 1 hour of post-traverse activities are required to conclude the EVA, as in EVA 1.

The pre-traverse activities of EVA 3, shown in Figure 8, require even less time than EVA 2 because transfer of consumables for a continued surface stay is not required. Traverse time is reduced to 3 hours and 40 minutes, however, due to increased requirements for post-traverse activities. During the final portion of the EVA 20 minutes are provided for activity associated with scientific equipment in the vicinity of the LM, and sample packing and transfer times are extended to allow for probable increases in these activities in the final EVA. The three EVA's are summarized in Figure 9.

CONSUMABLES AND TIME CONSTRAINTS

It is assumed that the A7LB suit and -7 PLSS will be used on these missions, and that the PLSS will have a capacity of 6400 Btu for metabolic rate related consumables and a capability of at least 6 hours for time related consumables. A 10% pad is provided for metabolic consumables available for the EVA. It is further assumed that the LRV will be available for all traverses.

Consistent with values currently agreed upon by the program (1), an average metabolic rate of 1100 Btu/hr is assumed for all activities except riding the LRV, which is assumed to be 700 Btu/hr. For walkback from a disabled LRV a metabolic rate of 1400 Btu/hr is assumed to correspond to a 4 km/hr lope. This value was developed to account for slope, surface, and wander effects. Most recent data seems to indicate that it is very conservative. It is further assumed that the SLSS as well as the PLSS may be used for walkback, providing 2400 Btu, or 6 km of walking capability (and 15 min. for LM ingress). It is conceded that the requirement for the use of both the PLSS and SLSS to provide walkback capability will rarely occur, and then only a portion of the SLSS will actually be required.

Figures 10, 11, and 12 are nomographs for use in the calculation of traverse distance versus science time for the 3 EVA's. An explanation of the structure and use of these nomographs has been published previously (2). Each chart shows the traverse time limit developed above for that EVA as well as the PLSS consumables limit after provision for the 10% pad and non-traverse activities. It appears from these charts that the time and PLSS consumables limits are evenly matched for the longer traverses, and that the first traverse is constrained by consumables.

SUMMARY AND CONCLUSION

For a 54 hour lunar surface stay three 6 hour EVA's and two 7 hour rest periods or two 9 hour EVA's and three 6 hour rest periods can be accommodated. Although 6 hour EVA's are consistent with limited PLSS capacity and short pressurized suit times, they result in long LO or TD days, or in back-to-back EVA's. The 9 hour EVA option requires increased capabilities, but provides an evenly balanced timeline with a normal 16 hours of activity between sleep periods.

Assuming that both the LRV and MALSEP are flown, associated deployment activities limit the LRV traverse in the first EVA to 2 hours and 20 minutes. The EVA 2 traverse is 4 hours long, and 3 hours and 40 minutes are available for the traverse in EVA 3. The high metabolic cost of the non-traverse activities in EVA 1 result in PLSS consumables limitations on the first traverse. The time and consumables limits are matched for the other two traverses.

The information developed here has been created to form a framework for the construction of lunar surface traverses consistent with the requirements and constraints of the J missions. Necessarily at this stage in the development of the lunar exploration program a large number of assumptions have been required to produce this framework. An attempt has been made to list these assumptions and their rationale. All of the assumptions have been based on the best information currently available with reasonable projections for increases in technological capability and confidence.

Any traverses based on this framework will be realistic to the extent that these assumptions are reasonable, and suggestions for modifications are welcomed by the author.

Peter Benjamin

2032-PB-tla P. Benjamin

Attachments
Figures 1 - 12

References

1. T. A. Bottomley, "Definition of Energy Costs for Lunar Surface EVA," Bellcomm Memorandum for File B69 09027, September 8, 1969.

2. P. Benjamin, "Handy Dandy Charts for Determining Operational Constraint Effects in Lunar Traverse Planning," Bellcomm Memorandum for File B69 10042, October 15, 1969.

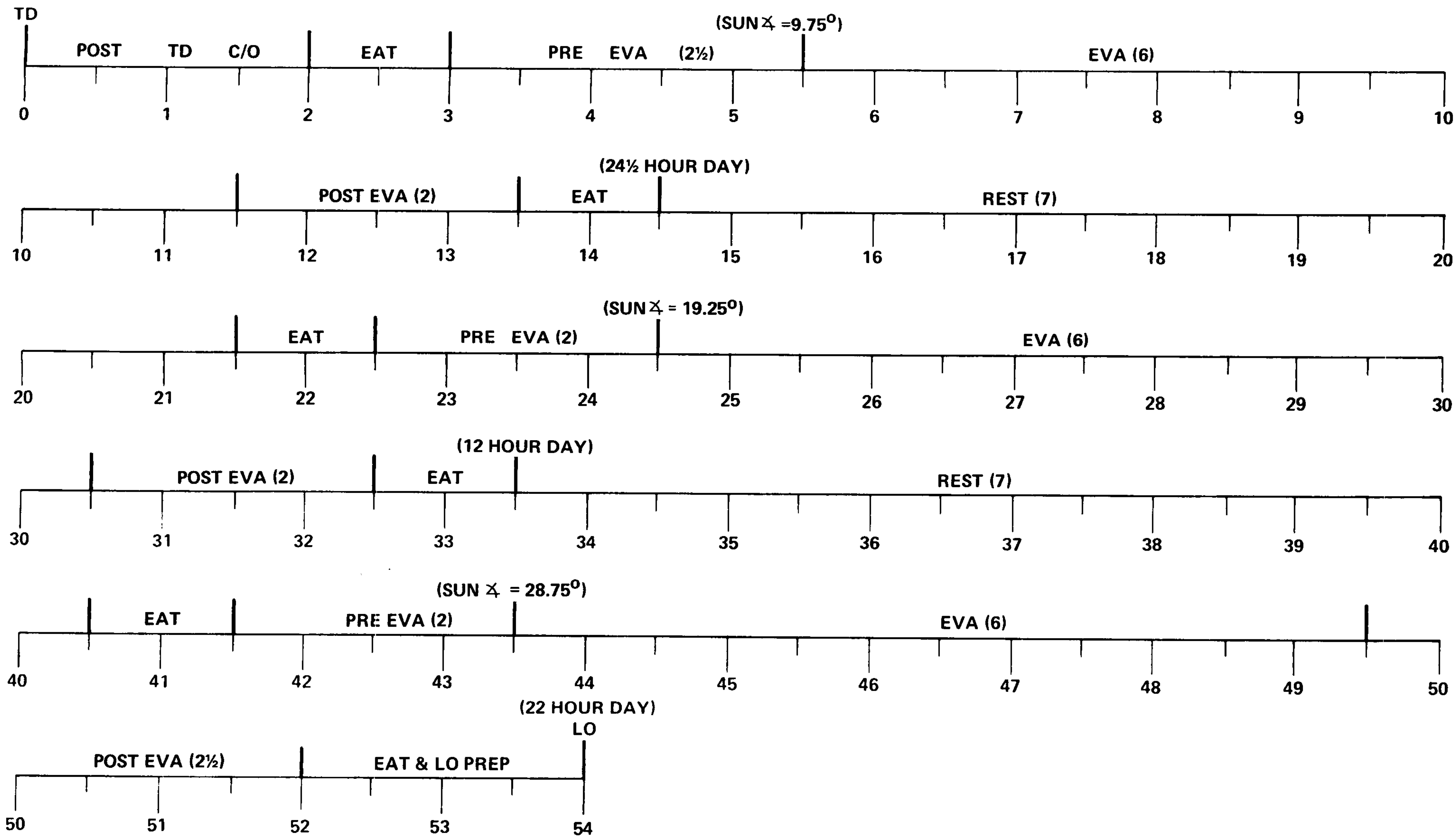

FIGURE 1 - LUNAR SURFACE STAY TIMELINE
PLAN A

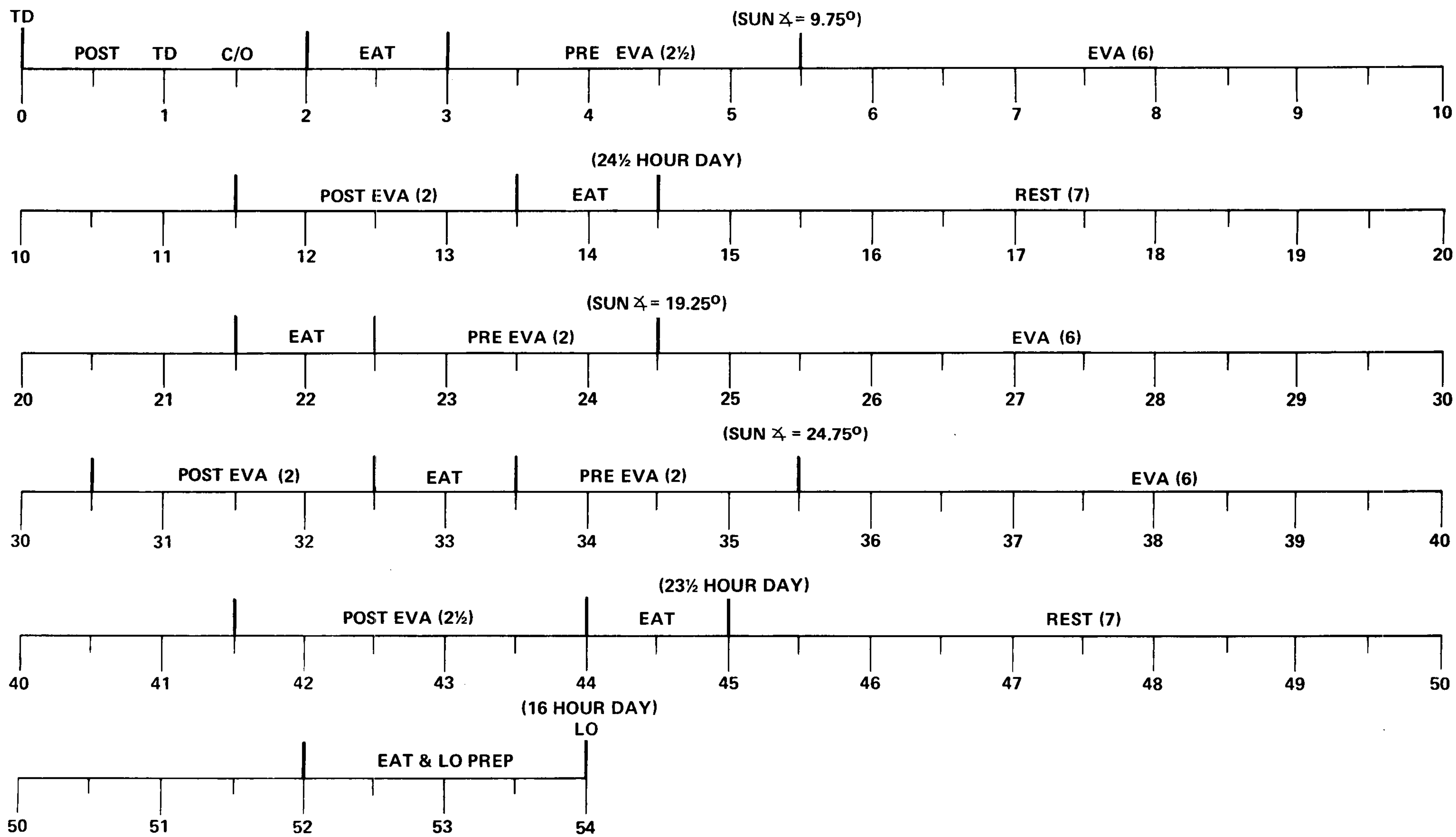

FIGURE 2 - LUNAR SURFACE STAY TIMELINE
PLAN A REAL TIME ALTERNATE

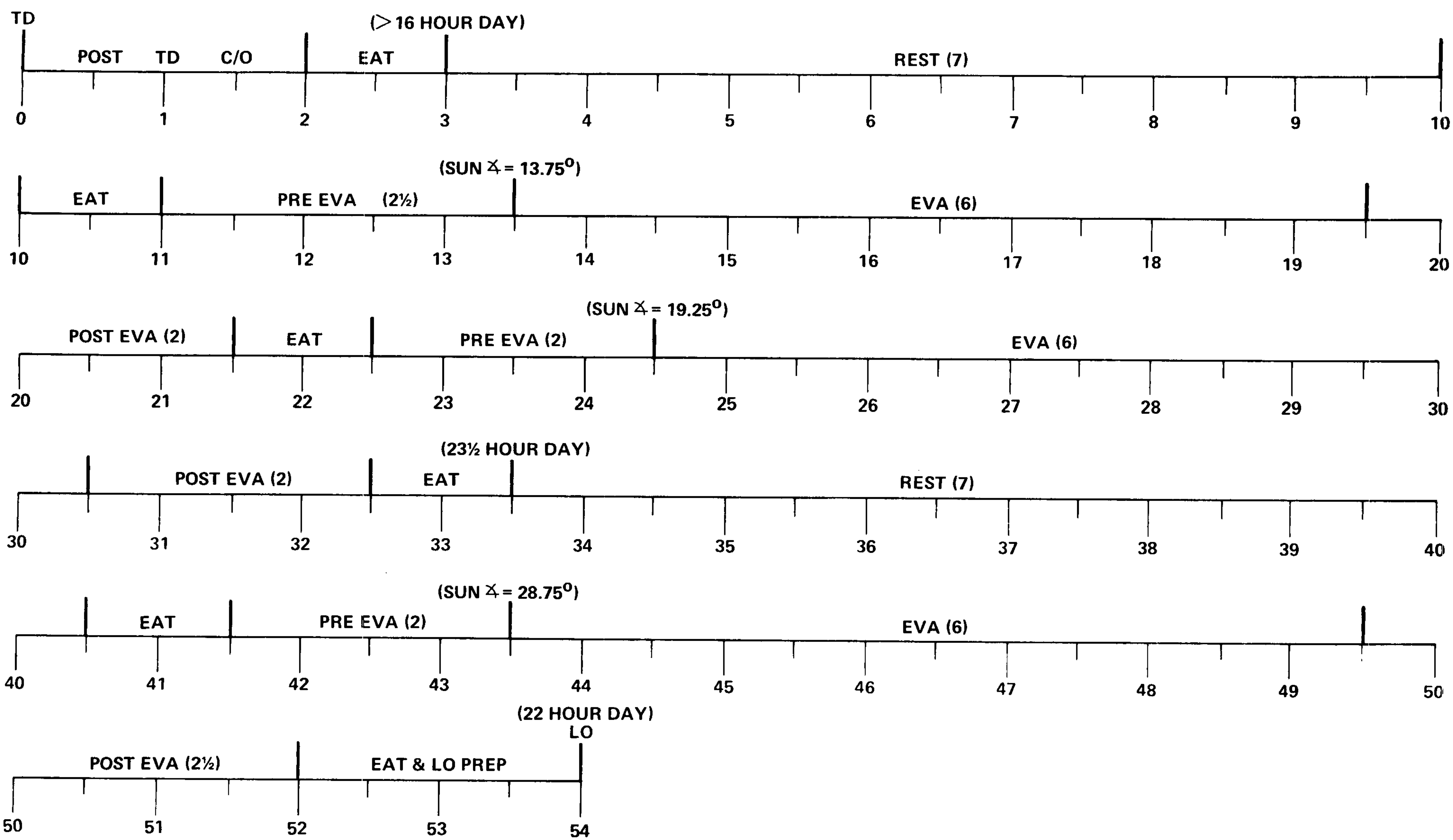

FIGURE 3 - LUNAR SURFACE STAY TIMELINE
PLAN B

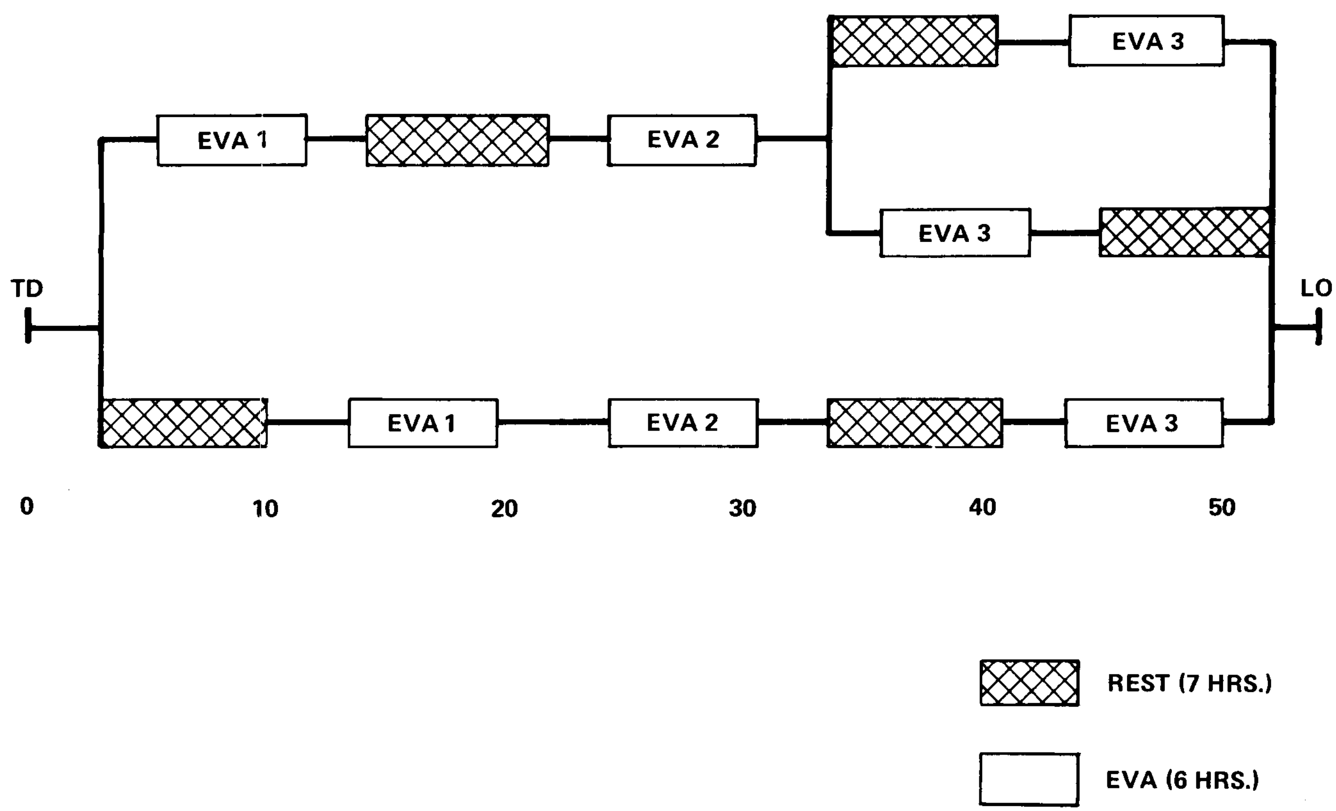

FIGURE 4 - TIMELINE SUMMARY

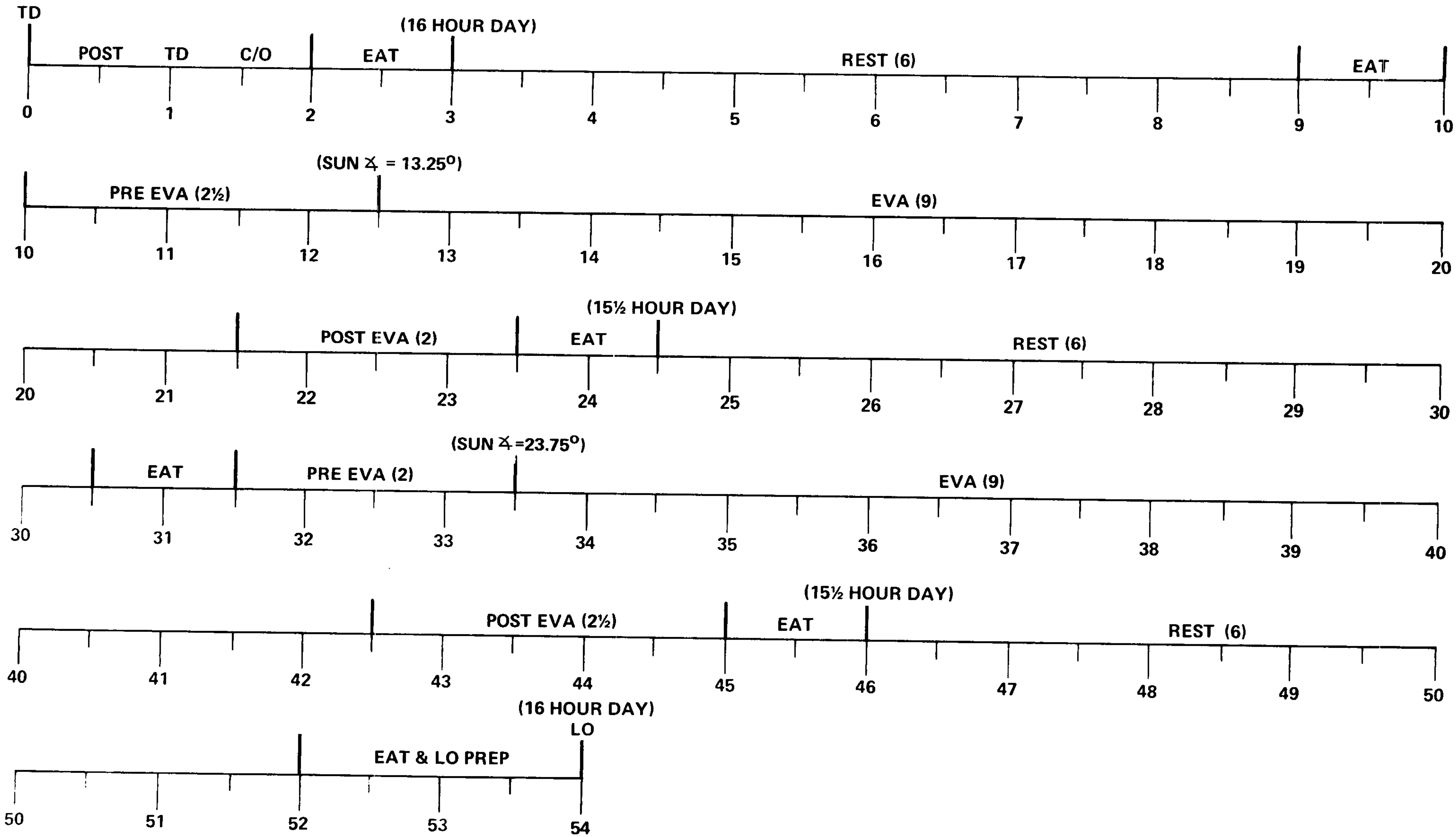

FIGURE 5 - LUNAR SURFACE STAY TIMELINE
EXTENDED EVA'S

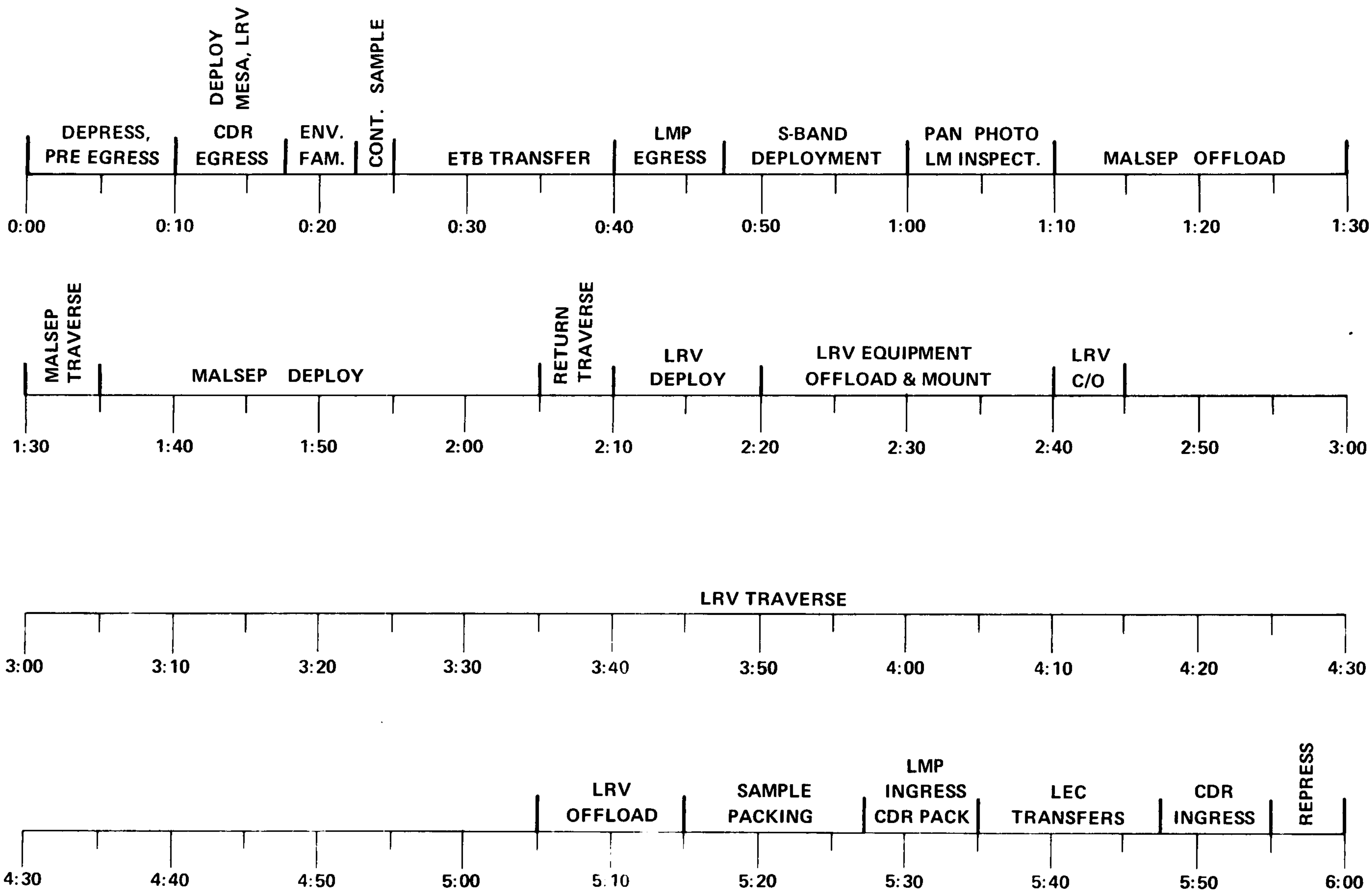

FIGURE 6 - EVA 1 TIMELINE
LRV TRAVERSE = 2:20

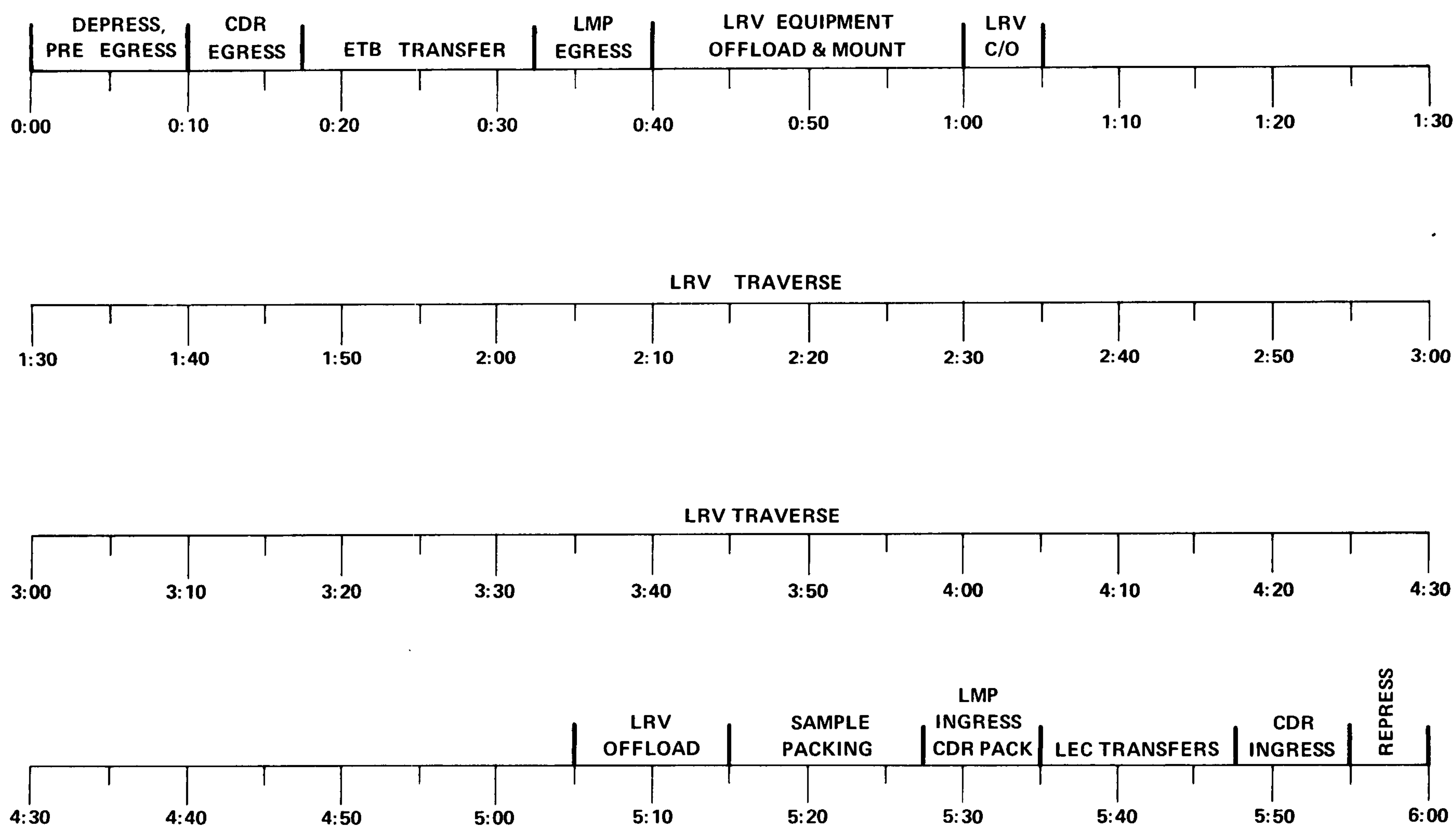

FIGURE 7 - EVA 2 TIMELINE

LRV TRAVERSE = 4:00

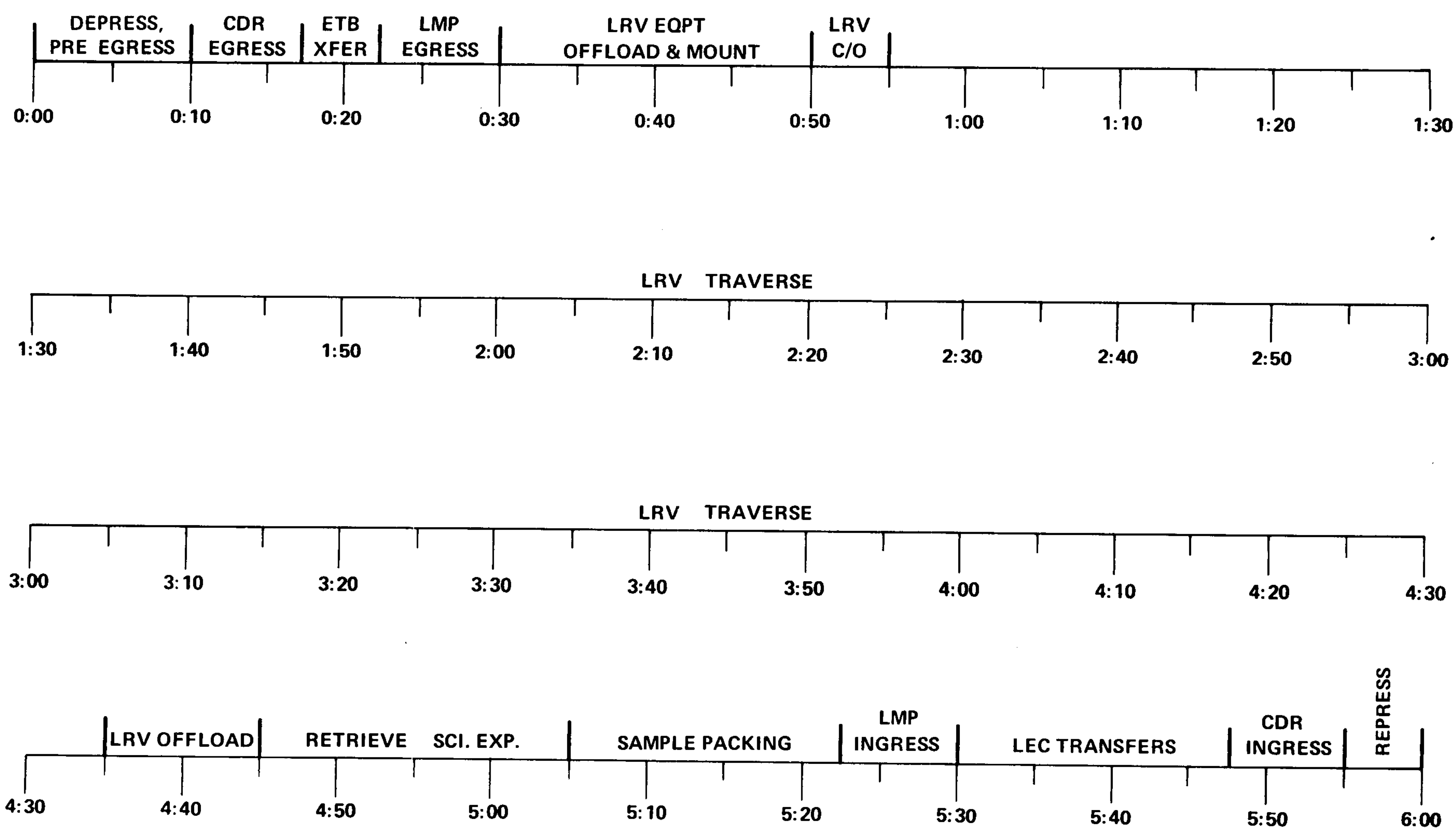

FIGURE 8 - EVA 3 TIMELINE

LRV TRAVERSE = 3:40

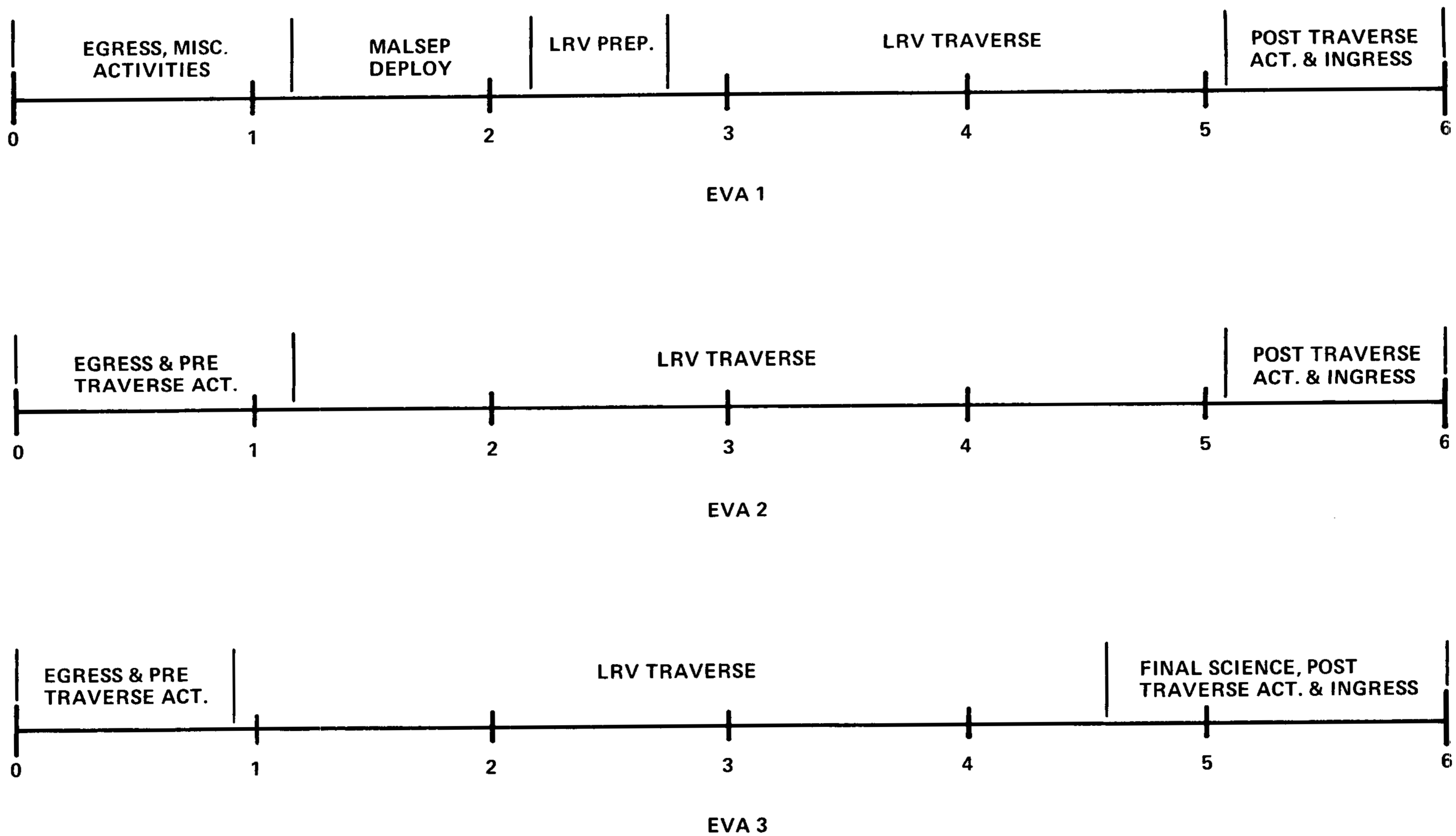

FIGURE 9 - EVA SUMMARY

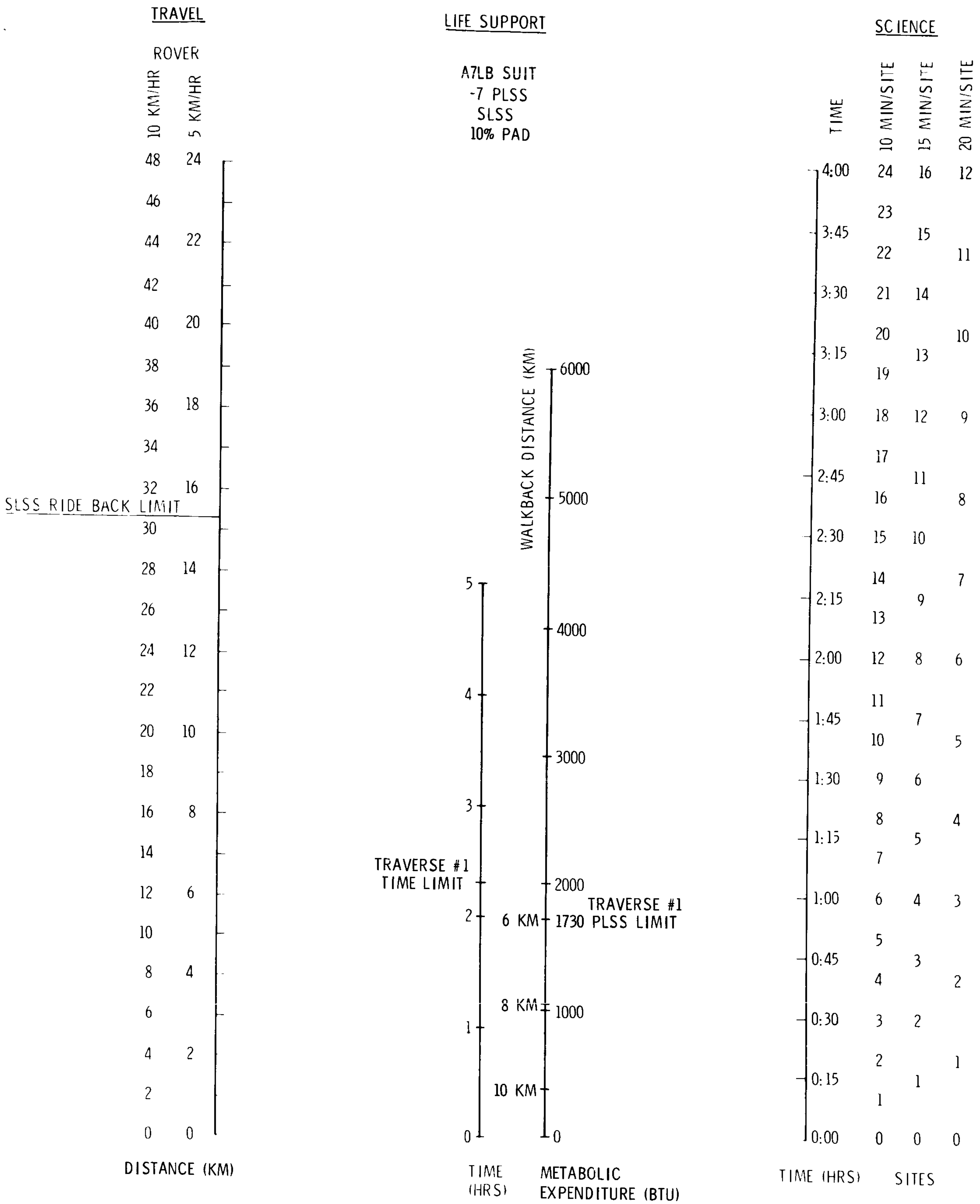

FIGURE 10 - TRAVERSE #1 PLANNING CHART

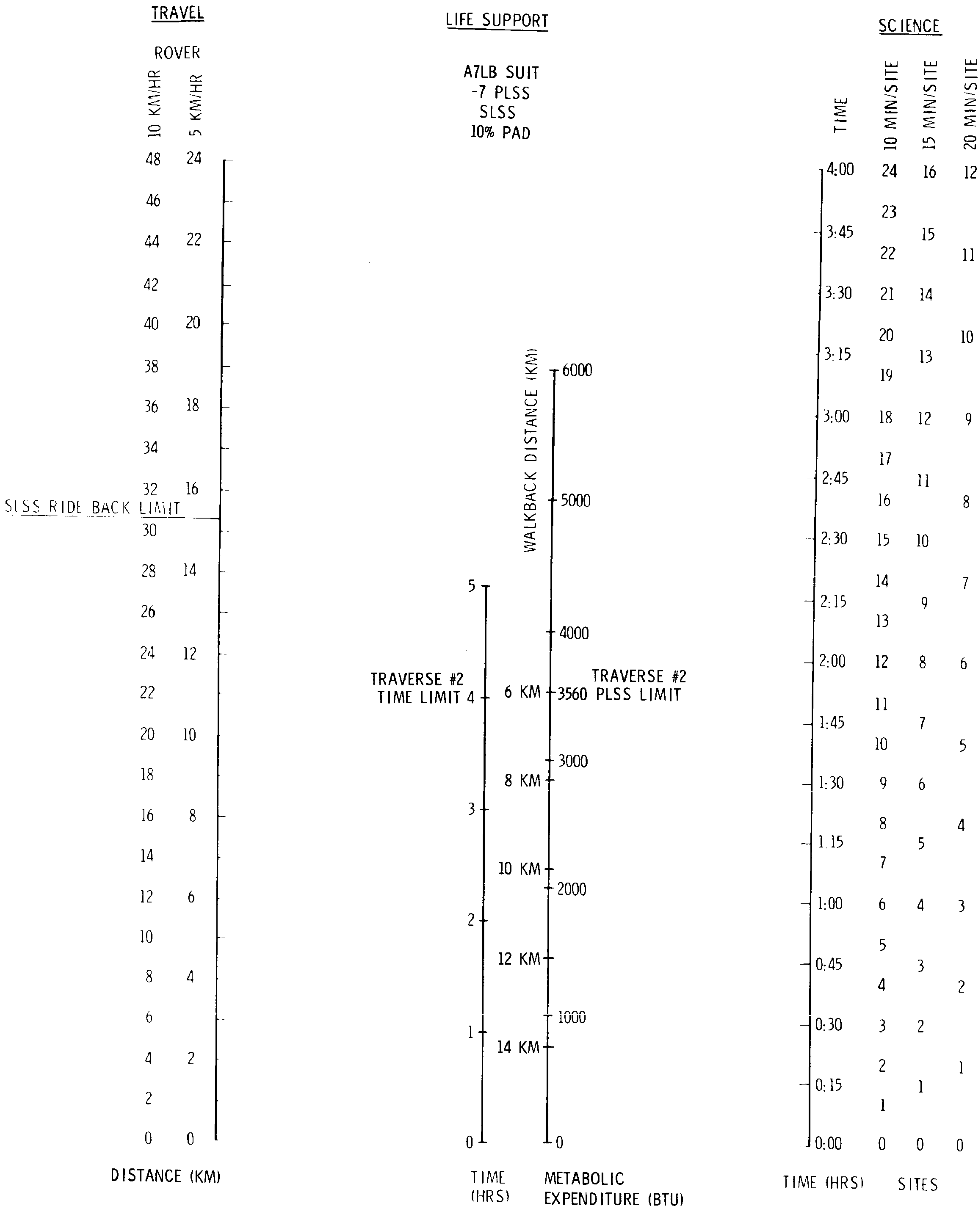

FIGURE 11 - TRAVERSE #2 PLANNING CHART

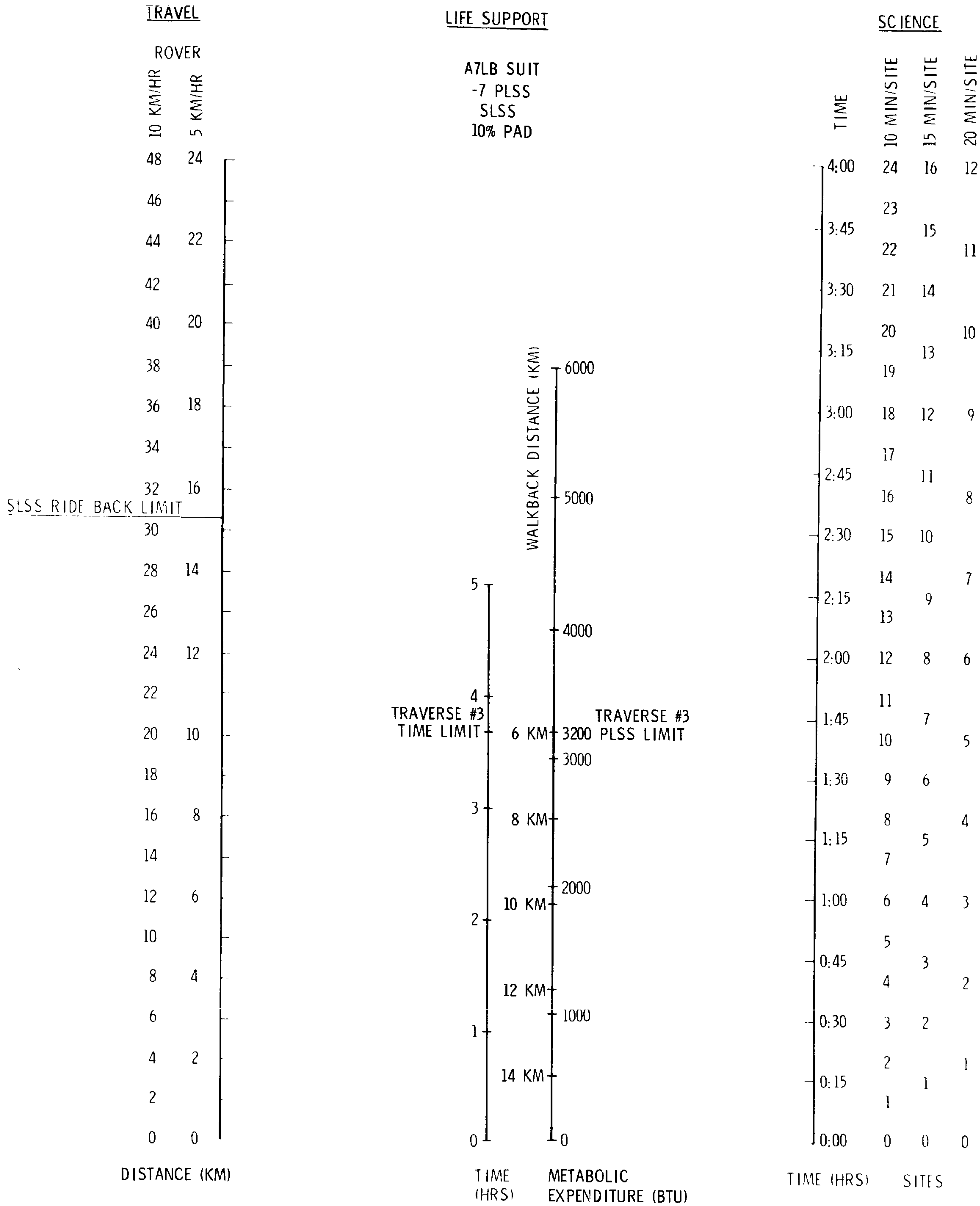

FIGURE 12 - TRAVERSE #3 PLANNING CHART

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